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# Adaptable design in Olympic Construction

## Abstract

**Purpose-** The Olympic Games is the largest sporting mega event of its type, with deep cultural and historical roots. The event is short lived compared to the lifespan of the infrastructure required in host cities. This research examines models of adaptability in Olympic construction, using case studies in previous Olympic host cities of the Summer Olympic Games (Rome 1960, London 2012) to assess the impact of adaptability on future legacy.

**Approach-** A mixed methods approach, (archival research, direct observation), was used in two case studies: Rome, (Palazzetto dello Sport, Palazzo dello Sport), and London (London Olympic Velodrome, London Aquatics Centre). The case studies examined how adaptability was used in the design of four buildings, designed by RIBA gold medal recipients, to secure legacy.

**Findings-** In the selected case studies, (Rome 1960, London 2012), adaptability has had a positive impact on the post Games use of venues, all four of which remain in use today. However, there are multiple factors that contribute to post-Games legacy, and further research is necessary.

**Limitations-** Some positive results were observed in this study, but more research is necessary across a broader spectrum of sites and venues to make conclusive recommendations for architects designing for Mega-Sporting Events. The comparative case study style approach used in this study could be the foundation for further research in this field.

**Social implications-** The significance of this study to architectural practice, academia, and society, is its potential to benefit future Olympic Games, IOC policy, and be extended to other Mega Sporting Events. In highlighting historical examples of successful post-Games adaptation and re-use of Olympic buildings the research could affect future Olympic building design and construction processes to secure a positive post Games legacy across Olympic venues.

**Originality/value-** The originality of this research lies within its analysis of Olympic infrastructures and sustainability, of which there is a current lack of comparative studies in academic research.

**Keywords:** Olympic Games, Sustainability, Building Adaptability, Architectural Design, Post-Games Use, Urban Design

**Paper type:** General review

## **Introduction**

The Modern Olympic Games are a unique and prestigious sporting event that serve as a platform to marvel at the incredulity of the evolution of the human body; to make good relations between nations, and provide the host country with the opportunity to showcase, via the media of contemporary architecture, its modernity, economic stabilisation, and social cohesion as a nation, to a global audience (IOC, 2012; Olympic Museum Educational & Cultural Services, 2013). Deeply rooted in historicism (Girginov & Parry, 2005) the Olympic movement is underpinned by a principal philosophy to promote human health and well-being through sport, culture, art and education, with a sense of unity and community. Since their inception in 1896, the Modern Olympic Games have proliferated exponentially in size and scope, with the Summer Olympic Games becoming the largest International Mega Sporting event of its type. The event lasts for less than three weeks, but the urban and infrastructural legacy that remains after the Games has ended has a much longer duration, and whilst construction for the Games has been used for the benefit of the wider community in some cities, there are several existing examples of 'negative' legacy outcomes in Olympic host venues, resulting in some criticism and resistance toward the notion. For example, all except one of the Olympic Venues of the Rome 1960 Games remain in use to date, on the contrary, the Helliniko Olympic Complex, Beach Volleyball Arena, and Softball Arena constructed in Athens for the 2004 Olympics were lying derelict by 2008 after geographical and cultural factors inhibited their continued use, and hosting the Olympic Games reportedly contributed to the collapse of the Greek economy, causing animosity amongst Greek citizens (Kissoudi, 2008). With the increasing societal and economical costs of hosting the Olympic Games, it has become a rising priority to address the issues of adaptability for post-use in Olympic construction; and to prevent negative legacy outcomes after the Games have ended.

## **The Olympiads: A Social and Cultural Background**

### *Cultural Significance*

It was established by Pierre de Coubertin, founder of the Modern Olympic Games, during their revival in 1896 that the Games ought to be held in a different location every four years (Chalkley & Essex, 1999) and it remains a stipulation of the Olympic Charter that the Olympics are entrusted to an elected, individual city each new Olympiad (IOC, 2015) as a means of promoting and diffusing the Olympic spirit of freedom, progress and equality throughout the world (Grupe, 1991). The host city provides the platform and backdrop to the Games and characterises each Olympic event with a particular context. In early editions of the Games this resulted in little more than assuming responsibility for provision of the necessary competition venues, but as the scale and scope of the Games increased, the host City became a stage to serve as the focal point not only for Olympic festivities but also celebrations that spread beyond the confines of the stadium; making statements of prowess and modernity that involve large scale investment to afford inherently expensive stadia, the accompanying elements of urban regeneration, and the adaptations to the infrastructure of the city required to accommodate the ensuing influx of tourists (Gold & Gold, 2007). The increased size of the Games has resulted in implications beyond the provision of sporting facilities and the organization of the event for athletes. For each of the Summer Olympic sports, a Summer Games city needs to prepare a multitude of competition and training facilities; one or more Olympic Village(s) to house athletes and National Olympic Committee (NOC) officials; broadcasting facilities and accommodation for journalists; improved airport capacity, public transport networks, and hotel accommodation to host out of city visitors and support the influx of

people; and supporting infrastructure such as water and sewage systems logistics, telecommunications and entertainment for effective operation (Chalkley & Essex, 1999; Liao & Pitts, 2008).

### *Impact*

It is widely recognised that high profile Mega Sporting Events (MSE's), such as the Olympic Games, have the potential to help to mobilise transformation of a city (Hiller, 1990; Hughes, 1993), community, or country, but they are often criticized for their political sensitivity and the large public expenditure required to adapt the existing city infrastructure (Hartman & Zandberg, 2015). One major impact of the Olympic Games is the sufficient momentum to intervene in the host city's short- and long- term development activities, placing unparalleled challenges and opportunities in the sphere of urbanization during the process of preparation. Another is the implied hosting milieu that cities need to rearrange their urban fabric and built environment to win the bid as well to safeguard the success of Olympic events (Liao & Pitts, 2008). Buildings constructed for MSE's can make a large contribution toward either the successful regeneration of deprived areas of cities, or result in a host of run down or abandoned facilities, a major driver in legacy debates (Hiller, 2006; Agha *et al*, 2012). Despite this, MSE's are generally perceived as worthwhile to host and organise (Hartman & Zanderg, 2015). Beyond urban regeneration and the provision of new sporting facilities to the city (Smith, 2014), there are many other benefits associated with hosting MSE's that are attractive to host cities, including place marketing (Mathewson, 2010), global audiences, television revenue (Whitson *et al*, 2006), strengthened international relations, employment opportunities, increased sports participation, and increased tourism (Gibson *et al*, 1998). The benefits of hosting a MSE range from political, infrastructural and temporal to place specific, and whilst the most common types of legacy are those of physical facilities, financial resources and community programmes, some of the most valuable legacies may be psychological or social in nature, such as, enhanced international awareness, image of the city and strengthened social structure enhanced by volunteerism (Richie, 2000). Conceived in many different contexts (Poynter, Viehoff & Li, 2016), event legacy can be both planned and unplanned, positive and negative, tangible and intangible (Preuss, 2007), and may be implemented using a top-down or bottom-up approach (Hartman & Zandberg, 2015). The most ambitious Olympic hosts have seen the Games as an opportunity to advance long term plans, accelerating the pace of change and pioneering the implementation of new planning concepts for the betterment of the city (Gospadini, 2002). Using the influx of income generated from winning the bid to become host city as a means to regenerate urban areas allows change to occur at a much faster rate than would normally be achievable (Horne, 2011), but the event-led approach to urban policy does not fit neatly into any of the accepted style or models of town planning or trend planning, as it is not led by government investment or by the dictates of private companies.

### *Sustainability*

The words 'sustainability' and 'Olympics' could be considered mutually exclusive. Transporting and accommodating athletes, coaching staff, Olympic officials, worldwide media, sponsors and spectators over a succinct period of time in one city for the duration of the event represents a significant use of resources and energy with a clear negative impact on the environment. Increasing concerns of gigantism and polarization of the modern Olympic Games probed the Olympic Games Study Commission in 2002 to evaluate a possible reduction in the number of events, participants, procedures and costs for future Games, (Pound, 2002), but despite concerns over its sustainability, the significance of the Olympics on

the world stage is such that its abandonment is culturally and financially inconceivable to many athletes, spectators and the media. Moderation to the structure and organisation of the Olympics would intrinsically detract from its original purpose, and regardless of any modification, the Games will remain a high-profile event (Liao & Pitts, 2008), with significant opportunity for the host cities to enhance their infrastructure and initiate environmental revitalization (Liao & Pitts, 2009).

Designing for the Olympic Games is not only about designing for the event, but the consideration of adaptability and post-use after the Games, adhering to the constant state of evolution within society (Lombardi & Brandon, 1997; Harvey, 2014). The importance of sustainable development and the environmental impacts of mega sporting events have commanded increasing political and media attention (Collins, Jones & Munday, 2009; Raco, 2015), ensued by an increasing pressure to ensure that sustainable developments meet the needs of the present without compromising the ability of future generations (World Commission on the Environment and Development, 1987, p.54). The rationale toward sustainable urban development is to optimise architectural and urban forms through planning and design (Harvey, 2014). In the Olympic context, addressing local environmental deficiencies and steering the city towards a more sustainable form is generally considered as employing sustainable technologies in design at building scale, but there is an increased level of complexity at urban and regional level as this task is compounded by the existing urban fabric and the necessity to adapt existing urban forms (Liao & Pitts, 2009). The possibility to weave smaller Olympic interventions across the breadth of the existing urban fabric, or utilise existing urban infrastructure, has reduced as the Games increased in size and scale (Gold & Gold, 2007). Despite warnings by Pierre de Coubertin that permanent stadia should not be constructed with the intention to host future events when temporary buildings would satisfy the Olympic demand (IOC, 2000), the ephemerality of Olympic Villages began to decrease during the Twentieth Century in favour of creating more permanent edifices, and the temporary use of military barracks and camps to complement the city's hotel accommodation was replaced by new construction and urban regeneration (Munoz, 2006). As the Games moved into twenty-first Century, and issues of sustainability began to arise, a shift back towards impermanent construction began to emerge if permanent building was deemed unnecessary.

### *Adaptability*

The model of adaptability is defined in its most holistic sense as the capacity of a building to accommodate effectively the evolving demands of its context (Schmidt III, 2009), including any major works to adjust, reuse or upgrade a building to suit new conditions or requirements (Douglas, 2006). The concept of adaptability is unique in Olympic buildings because the primary purpose for which the buildings are conceived is first and foremost to host an event of a short and fixed duration. The pressure on cities to host a successful event on a global stage (Kassens-Noor, 2012), often results in the creation of several bespoke venues in which there is an attempt to retrospectively repurpose after the Games have ended, rather than the post-Games use of the buildings remaining at the forefront of design throughout the process. The scale and format of Olympic venues can limit the opportunities for re-use as the specific infrastructural and size requirements for hosting the event are often difficult to comfortably negotiate for use by the local community post-Games. In the context of the Olympics, the economic costs of construction far outweigh event-mode use, a factor that has increased the significance of adaptability in Olympic design to prevent negative post-Games infrastructural legacy, which is fundamental to the understanding of Olympism in society (IOC, 2002).

When an Olympic building is converted from event mode to legacy mode, the building may change in terms of use, size, capacity, function, or performance (Douglas, 2006) with subsequent moderation (OECD, 1976). There are three general types of change that can be expected to occur within space over time: changes in the function of the space, changes in the load carried by the building, and changes in the flux of people and forces from the environment. Typically, Olympic Buildings demonstrate overcapacity for their use in legacy mode compared to their use in Games mode. Overcapacity is a characteristic that Gann & Barlow (1996) and Slaughter (2001) suggest increases flexibility when used in conjunction with separated building systems and prefabrication. However, the scale of construction for the Olympics is set to accommodate such a significantly increased capacity compared to its legacy mode use that the post-Games stadia often feel oversized and under-utilised. Increased size, height, and depth of buildings, and a flexible internal layout, are thought to enhance the opportunities for conversion into different uses (Gann and Barlow, 1996, and usually contribute to 'generality' (Arge, 2005), which is defined as the ability to meet changing user or owner needs without changing its properties. Design of Olympic Stadia is usually specific rather than general, and the typical radial format and intercolumniation makes Olympic stadia one of the most difficult typologies of building to repurpose for user(s). Furthermore, indeterminacy of use, which is suggested to enhance the adaptability of a building, can result in a sense of impersonality in post-Games stadia. According to Klanten and Feireiss (2009) the key to meeting the requirements of an ever-changing society in spatial terms is the ability to think and act flexibly within the field of architecture and urbanism, providing opportunities for growth and change. What is not implicit within many notions of regeneration or development is the ability of a place to shrink or contract within its lifespan. In recent editions of the Games, the problem of reducing 'overcapacity' for post-Olympic use has been addressed by a shift toward the use of temporary construction, or elements of temporary construction in design (Grant-Long, 2014). The incorporation of more impermanent and semi-permanent venues for the Olympic Games, bringing together both event and legacy requirements, is based upon a business case for venues when the Olympic site is in legacy mode. Repurposing, reusing, and even relocating are amongst the various strategies employed to secure a long-term legacy by adapting the infrastructure to incorporate new performance requirements and cope with the changing needs of owners and users. The erection of temporary facilities is a proven means not only of reducing the environmental impact of the Games but also of eliminating the long-term burden of maintenance or reducing maintenance costs to a tolerable level (Raco, 2015). Temporary constructions have been used in Olympic design but, despite removing the post-use burden of recurring maintenance costs and pollution, temporary buildings remain an economic and environmental encumbrance in terms of production, transport, erection, dismantling, and re-use or disposal (Meinel, 2001). For this reason, some 'temporary' stadia constructed for the Olympic Games have neither been dismantled or maintained, resulting in their dereliction (Brown & Cresciani, 2015).

In many building typologies, (for example, residential, industrial, school, and office), the cost of construction amounts to only ~20% of the entire lifecycle cost of a building (Meinel, 2001); therefore, it seems an obvious step to involve the building manager from the outset in decisions on the allocation of space and rooms for major event and post event use. In Olympic construction, the future building manager and user is not always known, which poses difficulties in planning for adaptability, and in many cases impacts upon longevity or lifecycle. In some cases of the Olympic Games a strategy of urban clearance must be used to allow construction to occur in the limited timeframe offered to prepare venues for the event (Davis & Thornley, 2010), but once the original inhabitants are removed, the future development of a locale becomes uncertain, and resultantly, this removes the possibility for designers

and planners to consult local people about the future shape of the area, because the future tenants or inhabitants are anticipated, but in reality, unknown (Greed & Roberts, 1998).

### *Legacy*

As awareness towards issues of sustainability increased, legacy impact began to rise on the agenda of the International Olympic Committee (IOC). In 2000, the Olympic Games in Sydney were heralded as the first to truly address issues of sustainability in their planning. In collaboration with Non-Governmental Organisations (NGOs), and monitored by Greenpeace, the Sydney Olympic Games achieved a 'green status' that is now used as a benchmark by which to compare future Olympic Games (London East Research Institute, 2007). In cooperation with the Sydney Organising Committee of the Olympic Games (SOCOG), the IOC established the Transfer of Knowledge (TOK) programme, (subsequently the Olympic Games Knowledge Management programme (OKGM)), alongside event preparations. The OGKM Programme was the underpinning for the Olympic Games Impact Study (OGIS), born from the IOC's desire to develop an objective and scientific analysis of impact for each edition of the Olympic Games (IOC, 2006). Designed to improve the potential benefits of acting as host City, the OGIS aimed to help to develop a knowledge base of tangible effects and legacies by providing consistent data to communicate the benefits of hosting the Games. It was hoped that the study would contribute to the development of strategy for delivering positive benefits in host cities, and demonstrate a commitment to maximising beneficial impacts of hosting the Olympic Games (DCMS, 2005), enabling the IOC to fulfill two of the principal objectives outlined in the Olympic Charter: to promote sustainable development in sport, and to promote a positive legacy from the Olympic Games to host cities and host countries. The OGIS proposes a set of indicators to measure potential impacts of the Games in a consistent manner from one edition to the next, providing quantitative and qualitative measures of the changes, or outcomes, caused by hosting the Games. However, identifying and attributing direct causality to the Games is difficult and complex, and there is no single measure that can be used to define impact. Instead an assessment must be made across a range of criteria, which can then be related to baseline situations, or the context of the evolving city, region and nation within which the Games take place (IOC, 2006). The scope of the OGIS covers the three internationally recognised areas of sustainable development (economic, sociocultural and environmental), over a period of twelve years, commencing two years prior to the host city election, and continuing three years after the Games have been staged.

The structures created for and by sport events that remain longer than the event itself, are intrinsically linked to all aspects of economic, environmental and socio-cultural legacy, but the concept of Olympic legacy is not always perceived in positive terms. Whilst some facilities are used for decades after an event, as per Rome 1960 and Munich 1972, others become forgotten almost instantaneously: Athens 2004 and Rio 2016 (Hartman & Zandberg, 2015). Successful legacy in one aspect does not necessarily result in successful legacy in another, and outcome cannot be singularly linked to any one factor (Chernushenko, 1994). Regardless of the form that a legacy may take, the underlying principle of legacy creation is that it represents something of substance that will enhance the long-term well-being or lifestyle of residents in a very substantial manner, preferably in a way that reflects the values of the local population. The increasing demand to generate positive legacies from MSE's has resulted in the emerging field of legacy planning, defined as planning for long-term benefits in host generations (Richie, 2000). Subsequently, the demand on civic infrastructure, the temporary population influx, and the increasing cost of the Games has resulted in only cities of concentrated regional economic power

being able to afford the financial commitment of hosting the Games, creating geographic inequalities by leaving out smaller city hosts.

The infrastructural legacies of the Games have a much longer lasting impact locally, regionally and nationally. In addition, there are significant overlaps between some of the categories, significant differences in the timeframes during which analysis took place, different geographical definitions have been used, accounts were collected by different researchers, some of the impacts have not been quantified, or where they have been quantified the units of measurement are not the same, and where data for was unavailable in a consistently sufficient, complete, or detailed form, the results for those indicators are omitted from the report (DCMS, 2005). Whilst the study, in principle, is a positive step towards assessing the legacy and sustainability of the Olympic Games, there are some limitations in its design, and lacks a completed inventory of sports venues in post-Games use because of the timescale within which it is executed, despite the architecture of the Games being recognized by the IOC as intrinsic to issues of legacy and sustainability. In 2001, the IOC hosted a conference 'The Olympic Games and Architecture: The Future for Host Cities', which served as a forum by which to exchange ideas, experiences and expertise (Isozaki, 2001), and subsequent to this 'promoting positive legacy' was inserted into the Olympic charter for the first time in its history in 2003 (IOC, 2003). It was a recommendation of the conference in 2001 that guidelines should be improved to: achieve compatibility of architectural quality and functionality in permanent and temporary facilities, meet the short and long term needs of a city in conjunction with the Games requirements, enhance and regenerate cities, achieve balance and integration between best use of existing, new and temporary facilities, and maximise legacies through facilities (Isozaki, 2001).

## **Methodology**

As part of a broader research project examining the urban and architectural legacies of the Summer Olympic Games, as the Winter Olympic Games is a very different cultural product with disparate infrastructural requirements, in Post- Second World War Europe. The historical and geographical limits are crucial to this research as the disparities between Europe and other Continents, or before and after the end of WWII are so huge that a comparative study would be impossible. This paper seeks to identify what adaptability means in relation to Olympic design, construction and legacy, highlighting some historic examples of adaptability in Olympic Venues. The aim of the research is to historic examples of adaptability in design which could influence the design and construction of future Olympic buildings to promote positive legacy outcomes.

Case studies are commonly used in research for the purpose of demonstrating and learning (Scholz & Tietje, 2002), and use of historical precedent in architectural research and practice is demonstrably effective as a method of analysis to improve future strategy and design. Research by Mulhuish & d'Avoine (2005) arose fundamentally from the principle of creating a reproducible formula for housing based on existing exemplary design with inherent quality and originality, but the ability to respond to different situations and contexts, both physical and cultural (Mulhuish & d'Avoine 2005). This same concept of 'learning from the past' was applied in urban disciplines, when it was proposed that urban renewal and suburbanisation in the late Twentieth Century had been centred round creating objects rather than good urban spaces that served the people (Project for Public Spaces, 2000). Research conducted by Liao and Pitts (2009) "to investigate the Summer Olympic events and their host cities, and to carry out analysis to aid in the development of more sustainable future Games" (Liao & Pitts,



2009, p.219) advocated promotion of knowledge transfer and continual development of better techniques to reveal potential problems, direct actions and indicate progress. In a comparison of urban features between Summer Olympic sites Liao and Pitts (2009), in a comparative study of the urban features of Beijing (2008) and London (2012), and Grant-Long (2014), in the 'Olympic Urbanism: Rome to Rio' project, used both archival and field research to develop a comparative evaluation framework by which to record and analyse Olympic urbanism outcomes in order to provide recommendations for recalibrating Olympic urbanism in future Games (Liao & Pitts, 2009; Grant-Long, 2014). Whilst Grant-Long's research remains unpublished, Liao & Pitts (2009) identified that the environmental performance and impacts of Olympic schemes can be evaluated, compared and improved by using assessment techniques at urban scale and for individual venues, but recommended that their data may need to be expanded, calibrated, and corrected over time with the evolution of the Olympic Games, forming the basis for further study and development (Liao & Pitts, 2009).

With a focus on adaptability in design, the study was conducted in the cities of Rome (1960), and London (2012), to assess the models of adaptability implemented in the construction of two Olympic buildings in each city. These two editions of the Olympics were selected for their relevance to the broader research into which they are channeled, (both were post World War II Summer editions of the Olympic Games in Europe), and for their differences, (they are at different stages of their subsequent post-Games legacy, 57 and 5 years respectively, and used different intervention strategies). There is a multitude of literature and documentation considering the London 2012 Games because of its recent occurrence, and technological advancement that has resulted in the free availability and accessible nature of documents via the internet; but it is a contemporary site, and Rome 1960 provides contrast in terms of its legacy duration, (52 years difference).

The two selected editions differ hugely in many respects, a summary of the main data is displayed in the table 1. However, this is precisely one of the reasons to identify them. The scope was to 'measure' how adaptability in the design had an impact on the legacy of relatively 'old' edition (Rome 1960, 57 years ago) when the concept of legacy was not even included in the Olympic brief and how the latter impacted on a more recent one (London 2012, 5 years ago).

The Palazzetto dello Sport and the Palazzo dello Sport in Rome, and the Aquatics Centre and Velodrome in London are the selected buildings, described in terms of their original intention and purpose, (derived from literature and archival documentation), their post-Games adaptation, and their subsequent and current use, (derived from direct observation). Considering models of adaptation in construction, features of adaptability in each of the case studies is discussed and analysed, and from this, a qualitative analysis is conducted to assess how adaptability has affected post-Games, community use, and how successful that adaptation has been in terms of legacy.

The choice of these buildings is determined by the fact that their designers (Nervi, Hadid and Hopkins) had experience on designing previous sport arenas and they are all widely renown as very capable building designers and recipients of the RIBA Gold Medal.

The following data was extracted from Official Reports of the Olympic Games in Rome 1960 and London 2012, available online, from the archival materials available at the IOC Studies Centre in Lausanne, and from existing studies. Highlighting the exacerbation of size and scope of the Games between 1960 and 2012 in the increasing number of athletes, disciplines and events.

Year of Games	1960	2012	Difference: London-Rome
City	Rome	London	-
Country	Italy	United Kingdom	-
Dates	23 <sup>rd</sup> Aug - 17 <sup>th</sup> Sept 1960	27 <sup>th</sup> Jul – 12 <sup>th</sup> Aug 2012	+ 52 years
Athletes	5,338	10,568	+ 5,230
Disciplines	23	39	+ 16
Events	150	302	+ 152
Total Venues	24	32	+8
Venues in the City	17	31	+14
Existing venues	5	17	+12
New venues	12	15	+3
Temporary	4	7	+3
Permanent	8	8	0

Table 1: (Garroni, 1960; Liao & Pitts, 2009; Nimmo, Wright & Coulson, 2011; LOCOG, 2013)

### London 2012: A Case Study

The London 2012 Summer Olympic Games, aimed to benefit existing residents (Davis, 2014) by achieving a legacy unprecedented in previous Olympics. Implementing a strategy to deliver 300,000 temporary seats, London 2012 delivered 32 competition venues: 7 new temporary venues, 8 new permanent venues, and 17 existing venues with overlay and minor permanent works. But whilst the notion of temporality appears to resolve many resounding legacy issues in practice, given the technical requirements and scale of venues for London 2012, the temporary arenas were delivered as bespoke solutions with the same performance specification as for a permanent building (Nimmo, Wright & Coulson, 2011), removing the benefits of reduced costs and delivery timescales that the use of temporary building implies. The major permanent venues of the Queen Elizabeth Olympic Park, designed by a variety of International architects rather than the same architect throughout, were not predetermined in terms of aesthetics or materiality.

#### *London Aquatics Centre*

Swimming has featured in all editions of the Summer Olympic Games since 1896. Over the years, it is not only the number of athletes and events that have influenced the increasing infrastructural requirements, but also the increased number of swimming disciplines, and of disciplines with a swimming component or the requirement for a controlled wet environment rather than open water. In the first editions of the modern Olympic Games the swimming events consisted of only Freestyle and breaststroke, but in 1904 backstroke was also included in the proceedings. Women's events, Modern Pentathlon, and Waterpolo, which made its debut at the Olympic Games in 1900 but was not included in 1904 or 1908 editions of the Games, were included in the events in 1912, and have been included in every edition of the Games since. Diving was included in the Games for the first time in 1904, with the addition of springboard and platform events in 1908, and women's diving in 1912. Since 1928, the diving programme has remained reasonably stable, with men and women taking part in both 10m high dive and 3m springboard events, although 2000 witnessed the inclusion of synchronised diving on both springboard and platform. In the 1940's breaststrokers discovered that they could travel faster by bring both arms forward over their heads, a practice that was immediately banned in breaststroke, but from which butterfly was born, making its first official appearance in the Olympic Games in 1956.

Synchronised swimming, the only exclusively female Olympic sport alongside rhythmic gymnastics, became an Olympic sport for the first time in 1984 with solo and duet events. This was replaced in 1996 by water ballet for 8 people, but since 2000 the Olympic programme has included both a team event and a duet (IOC, 2017).

London Aquatics Centre hosted the swimming, diving, Paralympic swimming and modern pentathlon events during the 2012 Summer Olympic Games, with an adjacent, temporary, water polo arena (Mara, 2011). Located within the Olympic Park masterplan at the South-Eastern Gateway to the site, the design of the Aquatics Centre addresses the main public realm spaces implicit to the park and Stratford City: the East-West connection of Stratford city bridge and the continuation of the space alongside the canal. Perpendicular to Stratford City Bridge, the building houses a 50m pool, a 50m training pool, and a 25m diving pool, along its orthogonal axis. The architectural concept for the design was inspired by the fluid geometry of water in motion, creating spaces and a surrounding environment in sympathy with the river landscape of the Olympic Park (ZHA, 2017).

Poised at the main entrance of the Olympic Park, the building was designed to be iconic and dramatic: a landmark in the Olympic Park (Dyckhoff & Barrett, 2012, P.80). It was designed by International Architect Dame Zaha Hadid in 2004, as London prepared their bid for the 2012 Olympic Games, awarded in 2005. Although no real site or brief had been prepared, the inclusion of the design by the International Architect and 2016 Laureate of the Pritzker prize, was thought to add architectural lustre to the Olympic scheme (Finch, 2012). When the venue was constructed between 2005 and 2011 it was as one of the permanent venues of the London 2012 Olympic Games, although its pre-Games inception meant that it was necessary to later adapt the design to make the building suitable to host the event, by increasing the spectator capacity. The ability to accommodate the size and capacity of the 2012 Olympic Games whilst also providing the optimum size and capacity for use in legacy mode was intrinsic to the design (ZHA, 2017), and was achieved by the addition of the temporary 'wings' housing 15,000 temporary seats covered by a temporary roof in addition to the buildings 2,500 permanent seats. When the temporary stands were removed, a glass facade enclosed the pools (Olcaydo, 2014), reducing the spectator capacity to 2,500.

Despite the reduction in spectator seating, (of which 17,500 seats would be wholly unnecessary in its use as a public swimming pool post-event), the volume of the main body of the building remained fixed because of the fixed roof structure and the necessary sight-lines for viewing whilst the temporary stands were in place. The curvature of the roof structure is significant to the concept of the design. The undulating roof is designed to sweep up from the ground in a wave-like form, enclosing the pools in a unifying gesture. Spanning two 50m swimming pools and a 25m diving pool in a column-less space (fig.1), to provide unimpeded spectator viewing, the underlying structure of the roof is an incredibly complex series of trusses, up to 12m in depth in part, used 3,000 tonnes of steel. Its underside, clad in 37,000 strips of red louro, a sustainable Brazilian hardwood, was laid parallel to the pool so that swimmers doing backstroke can use it for navigation (Dyckhoff & Barrett, 2012).

The floor area of the 36,875sqm building, which reportedly cost £269 million to construct in total including Stratford City Bridge, all construction, all transformation costs and VAT (Olcayto, 2014), was reduced to 20,264 square metres when the temporary seating banks were removed, compared to 42,866 square metres during the Olympic Game. This equates to a construction cost per square metre of £6,275 in Olympic mode, but £13,275 per square metre in legacy mode (Mara, 2011).

As consequence of the design, the glass façade constructed in the legacy refurbishment of the building to enclose the pool hall after the temporary seating was removed, resulted in direct solar light to the main pool hall, and a film had to be subsequently applied to parts of the glass to prevent glare and undue solar gain, (figure 1).



Figure 1: The undulating roof and column-free interior at London Aquatics Centre, in red, film attached to the glass façade to prevent solar glare but allow for natural daylighting, (Personal Archive, 2016)

### *Lee Valley Velodrome*

Track cycling was integrated as an Olympic sport at the inception of the modern Olympic Games in 1896, and has featured in every edition of the Summer Olympic Games since, with the exception of Stockholm in 1912 when only the road race was staged (IOC, 2017). Throughout its history, Olympic track cycling has taken place on both indoor and outdoor tracks, but primarily, where summer Olympic events have taken place in warm climates, the venues have remained uncovered. Whilst this reduces the costs imposed by constructing a covered venue, it inhibits the proceeding of events if adverse weather conditions occur during the Games, an untenable prospect for media coverage and public viewing, and limits the post-Games use of venues in countries with distinct seasons resulting in poor weather conditions for cycling and less sunlight hours in the winter months. The first partially covered Olympic velodrome was constructed for the Munich Olympic Games of 1972, and the first fully enclosed velodrome of the Summer Olympic Games was in Montreal in 1976, where the summer weather was uncertain. The last use of an outdoor track in an edition of the Games was at Atlanta in 1996, a temporary venue which was dismantled after the Games. Covered velodromes allow for finer control of the internal conditions to facilitate best performance in the sport, where warmer, less dense air increases sports performance by posing less resistance. Subsequent to Atlanta, all Summer Games cities including Sydney (2000), Athens (2004), and Beijing (2008), have hosted indoor track cycling venues. However, the indoor velodrome is not yet a stable archetype (Buchanan, 2011), and precedents from previous editions of the Games demonstrate a wide variety of sporting and non-sporting legacy and disuse.

Past Olympic and sport specific precedents were considered by Hopkins Architects, the winners of the design competition established by the Olympic Delivery Authority (ODA), for Lee Valley Velodrome, constructed for the 2012 Olympic Games between 2009 and 2011. The concept for the velodrome, focused around simplicity and efficiency, was conceived during an open design competition, which was, from the outset, open to Architects and designers who had previously never built a velodrome, on the premise that imagination and collaboration can often result in a more efficient and more beautiful building than one that follows convention (Serota, 2011). RIBA Gold Medalists (1994), Hopkins Architects, prepared a proposal which was selected from 8 shortlisted designs. It sought to manifest within the building the same design creativity and engineering rigour employed within bicycle manufacture (Pallister & Slavid, 2012) and deliver the smallest volume of all competition entries.

There are few prescriptive measures in the design of Olympic velodromes. The surface, width, circumference, tightness of bend and degree of banking for the track are not specified by the IOC, although they inevitably influence the overall design of the building and impact on athlete performance at elite level. The major protagonists in track design internationally, Ralph Schurmann and Ron Webb, provide different forms of track both utilised in Olympic construction. The former, with more tightly curved bends and longer straights is preferred in sprint disciplines, and was used in Beijing. The latter, facilitating a larger number of world records to date (Buchanan, 2011), was used in Seoul, Barcelona, Athens, Sydney and London. The track at Lee Valley, designed by Webb and constructed of Siberian Pine, is 250m in diameter with a banking of 42 degrees on the curve (Webb, 2011). It is often observed in velodromes that the spectator seating is configured only along the straights of the track, to adhere to spectator seating safety requirements stipulated for indoor arenae, where the banking is typically steeper, and because there is no necessity in outdoor arenae, where the straights are typically longer. In the Hopkins design for Lee Valley, the spectator seating is continuous around the circumference of the track, in an innovative configuration tested with the use of 3D modelling during the design process and acknowledged by cyclists as crucial to increasing cycling speed by facilitating continuous cheering from spectators (Buchanan, 2012). It was decided during the design that the spectator seating capacity of 6,000 was to be maintained after the Games (Pallister, 2011; Hopkins Architects, 2017) because of the false economy and high costs associated with constructing bespoke temporary facilities. Although the seating capacity of the velodrome is not frequently fulfilled in the daily legacy use of the venue, it increases variety in post Games use by maintaining the ability to host large-scale events in addition to its daily programme.

In contrast to many Olympic venues, the legacy operator for the London 2012 velodrome, Lee Valley Regional Park Authority, was known from the outset, and this contributed to the post-Games legacy of the venue being high on the agenda throughout the design process. The Olympic Games were treated as a 'housewarming party for the building', whereby the building was designed for its legacy use, but in a way that it would also work for the Games (Pallister, 2011). In designing a civic building with a lean structure, the building maintains flexibility for future adaptations to facilitate changes in program. For example, in the undercroft of the building, where the back of house accommodation is located, the spaces are divided by 48 concrete columns supporting the main bowl. In between the columns, ancillary spaces such as changing rooms are storage are housed, but non-required spaces were left to be designed when they were required (Personal conversation with Hopkins Architects, 2017).

The requirements of the local community were also considered in the Velodrome design. Aligned with a greater masterplan to rejuvenate the Lower Lea Valley in North East London, a strategy of urban clearance was employed during construction for the Games to allow preparation of the venues to be completed in the (relatively) short timescale associated with selection as host city. Whilst community consultation was sought to ensure that the post-Games legacy of venues benefited local residents and enhanced the local area according to their needs, the evolution of the local community, (exacerbated by the compulsory land purchase for preparation of the venues, and the new residential provision resulting from the conversion of the former athletes village), inherently altered the demographic of the area, creating a different demand to that of the expectation based on the previous occupants. Lee Valley Velopark, including the Velodrome and BMX track, is positioned on the site of the Eastway Cycle Circuit, (a 1 mile cycle circuit popular with the local cycling community), and the architects undertook an extensive programme of public consultation to ensure that the site, in legacy mode, provided an equivalent track for the road circuit users. As a result of this consultation, Hopkins proposed a slight shift of the building to improve the cycle circuit and maintain the Olympic BMX track, rather than demolishing and rebuilding it in another location. The resubmission for planning allowed the Architects to slightly alter the demarcated velodrome site, allowing them to remodel the roof, lowering the overall cost of construction, totaling approximately £105 million (Pop & Sans, 2012) by replacing the proposed roof with an innovative, structurally efficient, and economical double cable net roof using only 100 tonnes of steel compared with 1000 tons of structural steel for the Beijing velodrome of 2008. The 22m high concrete and steel structure of Lee Valley velodrome is clad in western red cedar. The Upper and lower seating tiers are split by the main public circulation concourse, forming the main point of entry into the arena in event mode, allowing ease and speed of access and egress. Elevation of the fully glazed concourse, prevented the necessity to excavate too far into the ground and provides uninterrupted views into and out of the building whilst visually separating the upper bowl from the ground floor back of house accommodation.

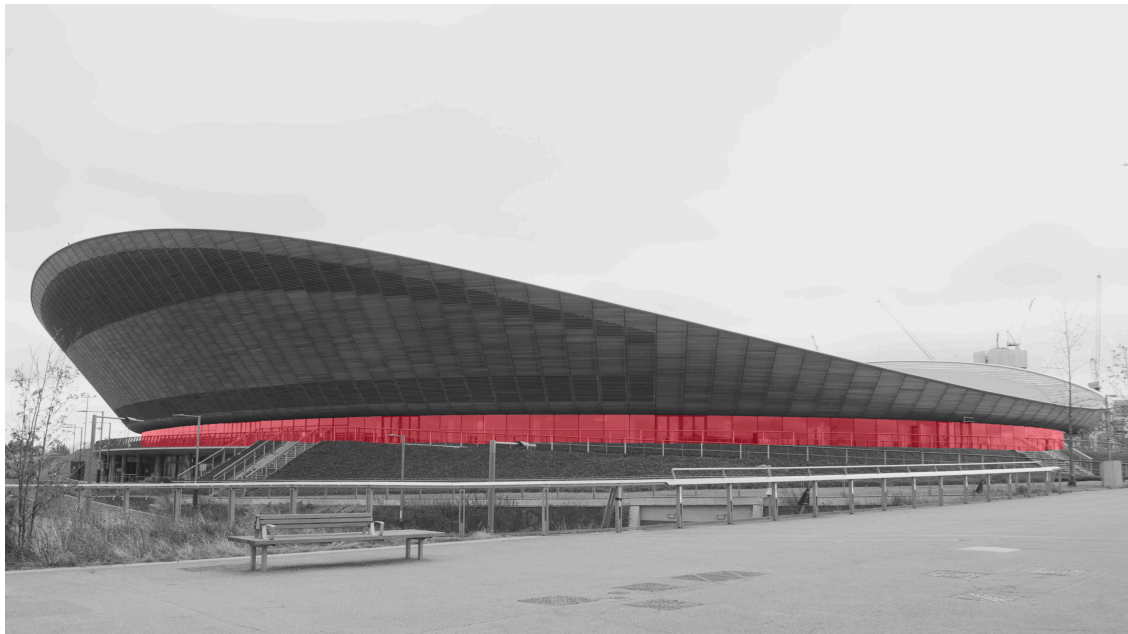


Figure 2: Lee Valley Velodrome, in red, the glazed concourse and event mode entrance, (personal archive, 2016)

## Rome 1960: A Case Study

Another example of adaptability in Olympic venues was provided by Rome in 1960. Only fifteen years after the end of WW2, Italy was still in its economical, and physical, phase of *Ricostruzione* (Reconstruction). The stringent limits of time and financial means, and the opportunities provided by the classic heritage of the city were turned into an advantage by the CONI (Comitato Olimpico Nazionale Italiano – Italian National Olympic Committee). Indeed some of the Olympic disciplines were hosted within some outstanding archeological sites. So, for example, Wrestling was performed in the Basilica of Maxentius and Gymnastic in the Caracalla's Baths. This smart and light approach avoided the costs of new constructions and provided an evocative background for the sport performance. However, even for the new sport venues, as the Palazzetto dello Sport and the Palazzo dello Sport (previously named the PalaEUR and now PalaLottomatica) both designed and built by Pier Luigi Nervi, adaptability was embedded in their design process.

Constructed in parallel, to complement one another as sport facilities in the City of Rome, the Palazzo and the Palazzetto were two of the major indoor sport venues used during the Summer Games of 1960, hosting Boxing, Weightlifting and Basketball, three sports with a long history in the context of the Summer Olympic Games. Men's weightlifting has been included in the Olympic programme since the first edition of the Games in 1896, with the exception of three editions of the Games, in 1900, 1908 and 1912. The programme for Olympic Weightlifting evolved significantly over this duration, until Sydney 2000, when Women's weightlifting was integrated into the programme, after which it has remained stable with men competing in eight weight categories, and women in seven. Boxing has also staged at each edition of the Games since its inclusion in the Olympic programme in 1904, with the exception of Stockholm (1912), as Swedish Law forbade the practice. Typically staged as 11 Men's events, at London 2012 this was replaced by 10 men's events and 3 women's events. The youngest Olympic sport of the three, Basketball first appeared at the Olympic Games in 1904 as a demonstration sport, but it was not fully integrated into the Olympic programme until 1936. Basketball has featured in every edition of the Olympic Games since, with Women's Basketball debuting in 1976, and was the main sport hosted in the Palazzo dello Sport during the 1960 Summer Olympic Games in Rome (IOC, 2017).

### *The Palazzetto dello Sport*

The Palazzetto was primarily conceived as an economical and multi-sport prototype, and, as such, to be 're-built' after the Games in other locations. Initially conceived by the CONI's Head Architect, Annibale Vitellozzi, the two main characteristics of this arena were an overall circular shape and the absence of any vertical structure within the building. The first one was motivated by structural reasons. A strictly symmetrical shape would have allowed an efficient prefabrication of the main structure with evident advantages both in terms of quality and speed of construction. The second one was to avoid any visual obstacles that would block the complete view of the arena; this was particularly relevant as the indoor sports performed inside would vary: from boxing to basketball. Indeed in 1960 the Palazzetto was placed close to the Olympic Village and served essentially as training gym for the athletes. This building is covered by the magnificent dome designed by Nervi a ferro-cement hemispherical dome that echoes the classic domes in Rome. It is one of the most famous structures designed by the Italian Engineer, who in the same year (1960), was awarded the RIBA Gold Medal. This building has been continuously used since 1960, a true testament of its resilient adaptability; however, it is worthy to report a minor fault in its design, which was an overseen consequence of the circular plan. Indeed, in the



south elevation of the building, the penetration of direct solar light makes problematic the performance of sport activities. This was immediately clear since the morning training session of the Olympic athletes in 1960 and still an issue today as can be seen by a recent photo (fig. 3). The Palazzetto, constructed in what was in 1957 the extreme outskirts of Northern Rome, is now fully immersed in the so-called Olympic district and surrounded by contemporary architectures as the MAXXI (by Z. Hadid) and the Auditorium (by R. Piano).

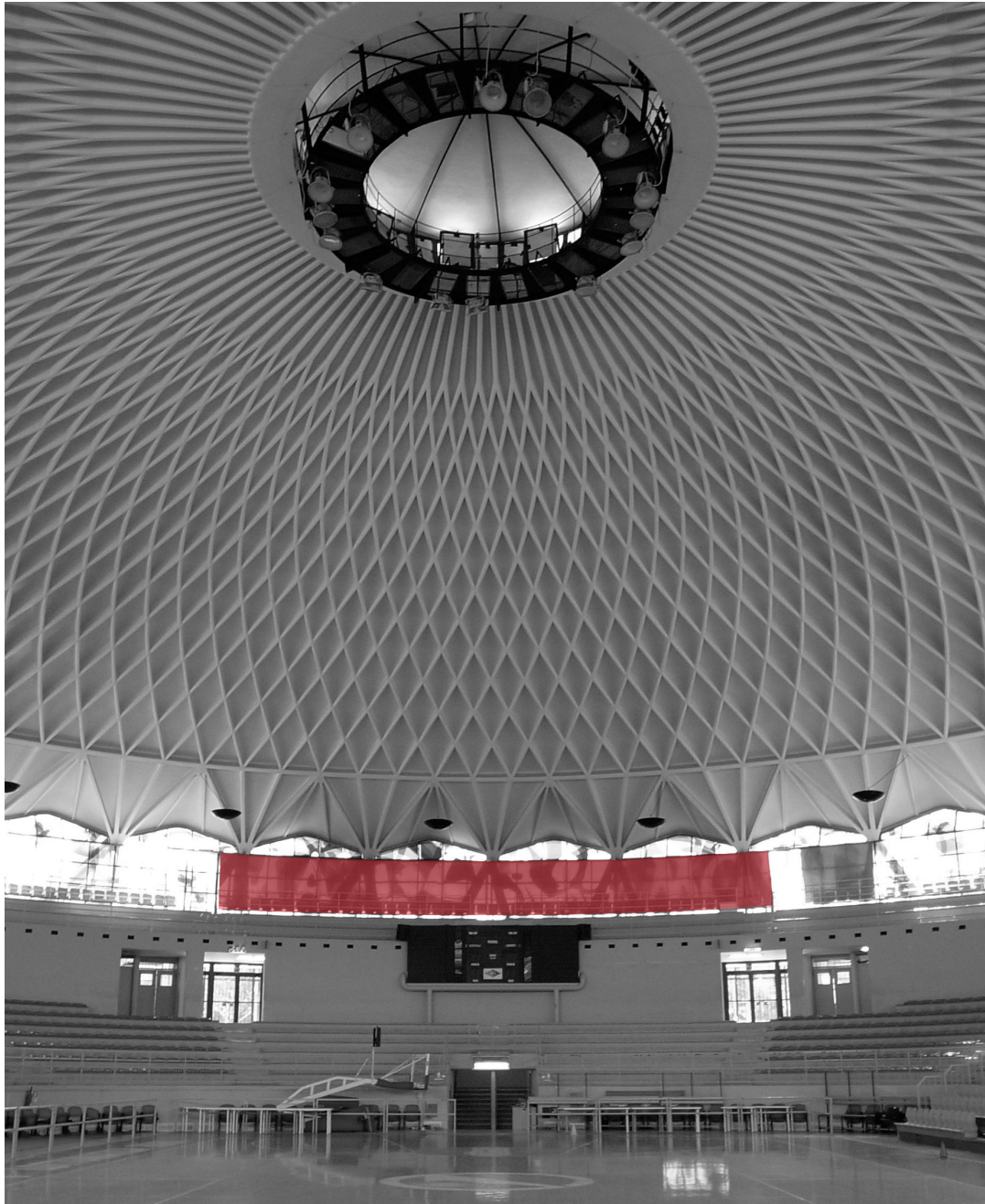


Figure 3: The banner covering the South elevation in Palazzetto, (Personal Archive, 2016)



### *The Palazzo dello Sport*

The Palazzo dello Sport, now commonly known as PalaLottomatica in the EUR District of Rome, featured in 1960 the largest dome in reinforced concrete in the world, now only surpassed by the Norfolk Scope in Virginia (also designed by Nervi). After almost a decade of scarce use due to non-conformity to legal normatives, in 2000 the iconic building underwent a major refurbishment to align security and safety features; The refurbishment works dealt with a series of issues, of which the most important were:

- The adjustment of the internal capacity (from 16,000 to 11,600 for sports events and 10,200 for non-sport events);
- The creation of new fire exits to adhere to the current Italian legislation in terms of security and safety in public buildings;
- The creation of a link between the external entrance and the internal hall to facilitate the transportation of large equipment within the arena;
- The insertion of mechanical devises to improve the overall acoustics of the hall;
- The replacement of the external glass façade and the organisation of the outdoor spaces.

The substantial architectural refurbishment, the only one occurred after its construction, was directly sustained by Nervi's right arm for many years, structural engineer Mario Desideri. The circular form of the Palalottomatica and its the large glass partition presented a much bigger issue than the Palazzetto in terms of solar gain. Indeed, records showed unbearable temperatures within the building over the Summer (approaching 40° Celsius). The architect Fuksas conceived a 384m long new façade employing an anti UV film which reduced the solar gain of 40%.



Figure 4: The new façade of the Palalottomatica (Personal Archive, 2014)

As a result of the works, the sport venue managed to have a second life as a multi-event venue. This was granted by the series of works above but also to the specific location of the large venue, on the outskirts of Rome, very well connected by the local transport link and provided by a new larger outdoor car park. Furthermore, the massive improvement of the acoustic performance of internal hall which now reaches a suitable acoustic standard for pop and rock concerts (Cresciani, 2014). The PalaLottomatica has been a member of the EAA (European Arenas Association) since 2014. This association represents 34 leading European arenas across 21 different countries dedicated to hosting the most innovative and popular entertainment in Europe, amongst these: the Olympiapark in Munich, the Palu Sant Jordi in Barcelona (both Olympic Structures) and the O2 Arena in London.

## **Conclusions**

The socio-cultural, economic and environmental costs of Olympic development emphasize the requirement for better solutions for adaptability in Olympic design. Olympic buildings must continuously evolve to fit functional, technological, and aesthetic metamorphoses in society (Schmidt III, 2009) and to transition from event-mode to legacy mode and their lifecycle beyond. Post-use of Olympic infrastructure demonstrates a mix of both successful and unsuccessful post-Games legacy, and previous research has evidenced the difficulty of attributing level and causality of success due to the nature and complexity of legacy and sustainability (Brown & Cresciani, 2015). The case studies of Rome 1960 and London 2012 demonstrate that adaptability in those buildings has had a positive impact on their post Games use. All four of the venues remain in use today subsequent to their post-Games adaptation.

At the urban scale, it is clear that the Olympic Games have been an implicit part of urban transformation in cities in the Western World over the course of the Twentieth Century (Viehoff, 2015). Olympic construction is becoming increasingly interwoven into urban economy and (re-) development schemes (Shoval, 2002; Gold & Gold, 2008) and both the London 2012 Olympic Park, and the venues of the Rome 1960 Olympic Games are exemplar of this. The experience of Rome 1960, in which the targets were to minimise the necessity of new constructions via the intelligent re-use of existing buildings, and design adaptable new venues for future use, is still seminal. In London temporary venues were installed to be subsequently deconstructed or repurposed for use elsewhere. But in both cities, there remains a legacy of permanent buildings constructed for the Games. With adaptation either a concept initiated at the design stage (as in London, and the Palazzetto), where the aim was to benefit the community from the outset, or a retrospective act (as in the PalaLottomatica), to revitalize an important architectural heritage within the city; adaptation has influenced the contribution of the building to the City's sport and recreational activities. Despite some successful retrospective adaptation of Olympic construction, for example, the Palalottomatica in Rome, which was re-established as a multi-event venue after refurbishment, there is evidence in literature to support the notion that the capacity for a building to respond to change is determined through decisions made early on in the design process resulting in the completed structure to ensure trouble free operations after completion (Meinel, 2001). Further research is recommended to support this statement in relation to Olympic design.

The significance of this research in industry and academia is its potential to benefit future Olympic Games and be extended to other Mega Sporting Events, with three specific outcomes. First, is to critically and comparatively analyse design strategies across each building typology, to identify the characteristics of design and post-Games adaptation that are attributed to current use and legacy. Second, the study builds upon current literature and policy, producing a current analysis of a cross

section of post-Games use in a representative sample of Olympic buildings as they currently stand in 2017. Third, the research has the potential to be considered by designers in the construction of future Olympic buildings. By establishing which aspects of adaptability have historically proven to be successful in precedent, designers have the opportunity to promote positive legacy through design.

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## Figures

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